Systems Thinking Assessment
of
MD Teams External Dynamics

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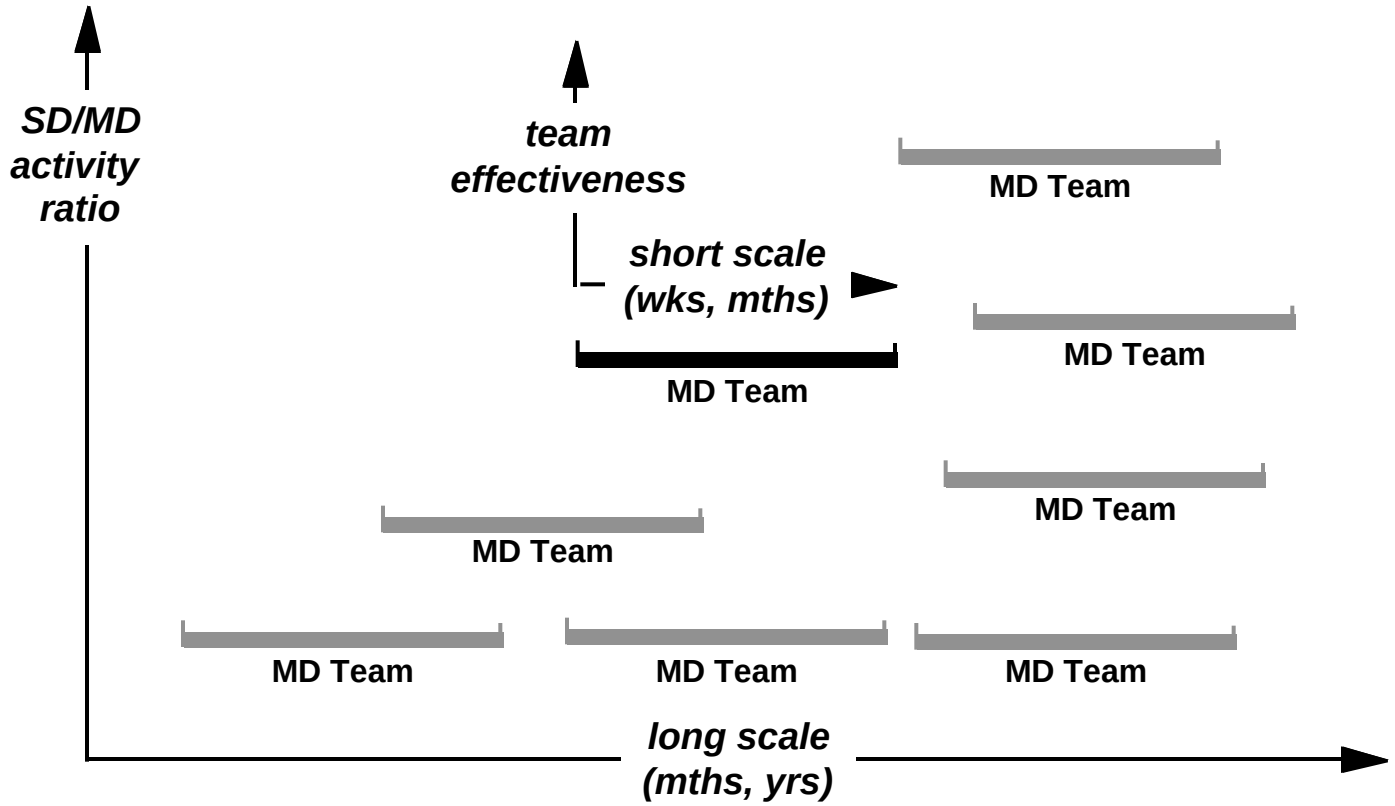
Objectives

- **Use ‘System Thinking’ techniques to assess the dynamics of the forces involved in the creation and maintenance of multidisciplinary teams at NASA/Langley**
- **Use the resulting assessments to identify high-leverage interventions**

Process

- **Interview selected participants on recently completed or on-going LaRC MD Teams:**
  - **HSR/LCAP (Longitudinal Controls Alternative Project)**
  - **ANT (Airframe Noise Reduction Team**
  - **MDO-DPT (MDO-Detailed Planning Team)**
- **Combine with team members experience in MD teaming and recently in ASPO project planning.**
- **Separate internal and external team dynamics**
- **Identify variables, causal relationships, external factors and mental models at play.**
- **Recommend interventions at the team member, team leader, line management, and project office level.**

External vs Internal Team Dynamics



Outline

- **Objectives**
- **Process**
- **Observations/Assumptions**
- **Assessment**
  - **Sponsor Commitment**
  - **Technical Maturation and Cost/Benefit**
  - **Competence/Competency**
  - **Researcher Affinity**
  - **LaRC *Modus Operandi***
  - **Technical Maturation Gap**
- **Currently Operating Dynamics**
- **Intervention Summary**
  - **Individual Researcher**
  - **Line Organization (Branch, Division, Group)**
  - **Program Offices**

Observations

LaRC Resources are expended either in SD or MD work

- **LaRC largely operates in a fixed resources environment, this translates in a fixed number of FTE's and/or $, for the sake of the discussion we'll think in terms of $.**
- **With those $, two kinds of activities can be carried out at LaRC: SD (SingleDisciplinary) and MD (MultiDisciplinary) activities.**

- **There has always been some level of MD activities at LaRC.**
- **There will always need to be some level of SD activities at LaRC.**

There is a need to increase the volume of MD activities relative to the total volume of research activities, as a consequence this will result in reduced volume of SD activities.

- **Over time, there have been deliberate efforts to alter the SD/MD balance at LaRC (IRO, HiSAIR, MDO-RRC/DPT, MDOB...), they have met with varied success, as a consequence, different mental models are in place.**

Observations

Many Organizations carry out MD work at LaRC

- **MDOB is the RTG organization tasked to carry out MDO methods development. It is also tasked to participate in MD application activities; it was not tasked nor staffed to carry out all MD applications, nor all related SD developments.**

- **MD work is carried out by other organizations within RTG or LaRC, but these organization do not have the charter to produce MD work.**
- **Since RTG and LaRC are mostly organized so that line organizations are aligned with SD competencies, many MD activities need to be carried out by horizontal cut teams.**

- **There is no infrastructure explicitly responsible for:**
  - **compiling a research portfolio with the proper balance between SD and MD**
  - **maintaining an MD core competency**
  - **grooming an MD workforce**
  - **retaining the experience gained in MD activities**

Observations

- **The balance between SD and MD activities (SD/MD balance) is now set by the program offices.**

- **Individual researchers as well as line management retain a significant indirect control on the SD/MD balance through their participation in the program office planning processes.**

Assessment

Key Variable

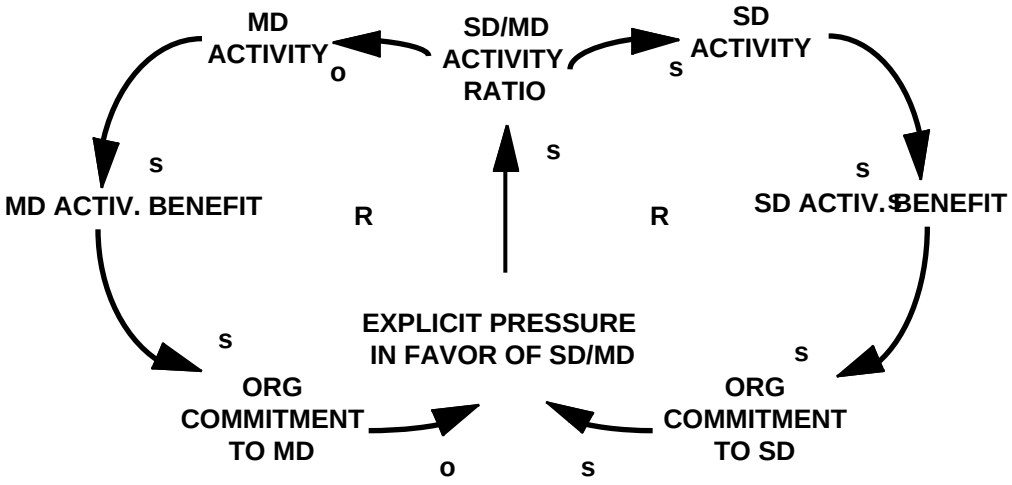
- **The key variable in the loops is the ratio between resources applied to SD and resources applied to MD activities (SD/MD). It is presumed to be large now and to need to be reduced, reflecting the fact that more MD activities are carried out.**

- **Two kinds of pressures are present which set this ratio**
  - **an explicit pressure, based on tangible, quantifiable factors**
  - **an implicit pressure, based on less tangible factors**

Assessment

SD (MD) Activities Build-up Sponsor Commitment

mm: ***MD has not done anything for me***



Assessment

Key Archetype: Success to the successful*

- **Structure:**
  - pair of reinforcing loops; a virtuous circle, and a vicious circle
- **Story:**
  - two activities compete for a common limited resource
  - as activity A's success increases, more resources are allocated to it, less resources are available to B
  - with less resources, B's success decreases and less recources are allocated to B.
  - key to the dynamics: resource allocation decision rule
- **Interventions:**
  + base resource allocation on potential and demonstrated success
  + look for overarching goal for activities A and B
  - break the resource link, if warranted
  - look for additional resources, if possible

*System Thinking-Productive Conversation, Participant Manual, Innovation Associates Inc. © 1996, NASA Ver. 96.7

Assessment

SD (MD) Activities Build-up Sponsor Commitment

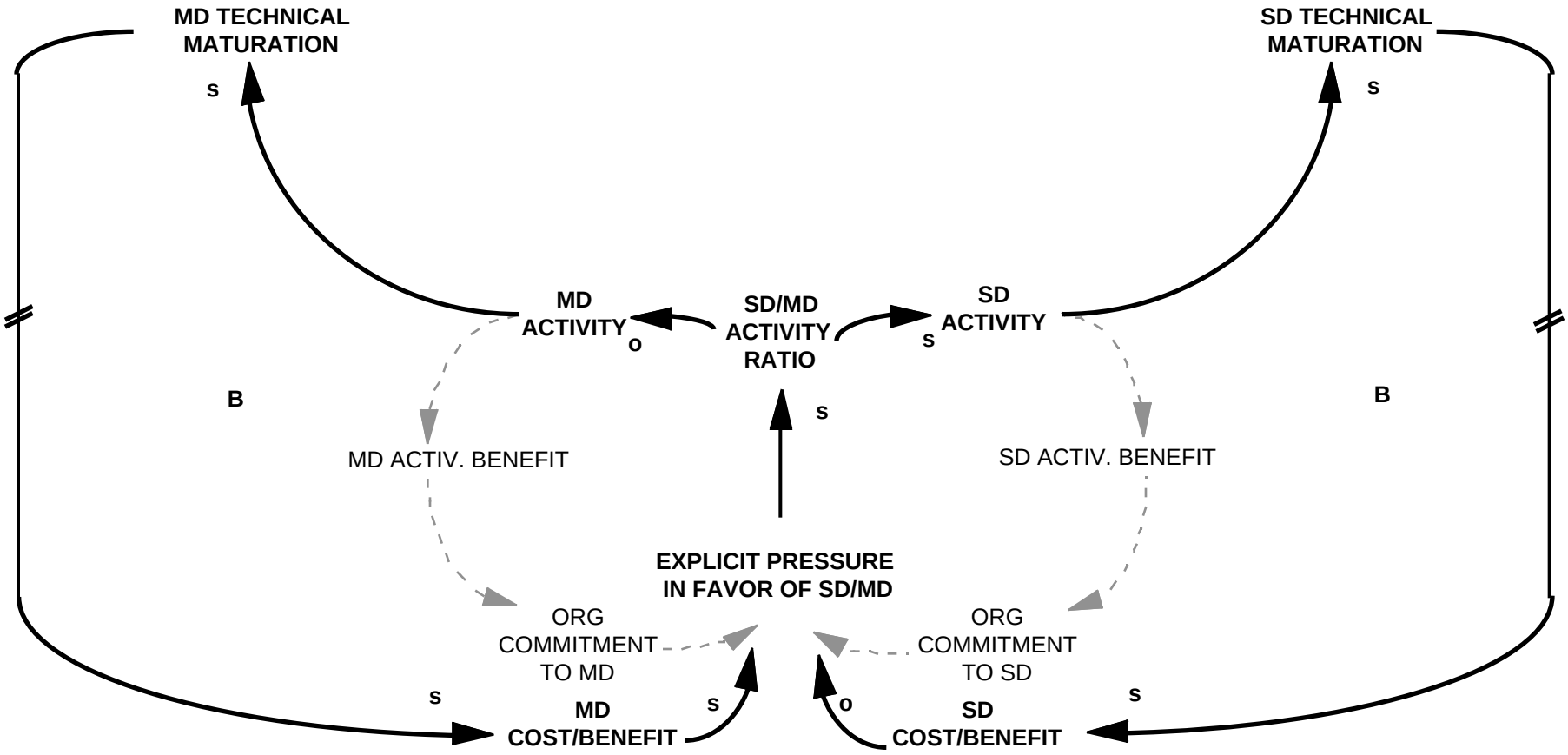
- **Key Structures:**
  - **increasing SD (MD) activities results in SD (MD) benefits, improved sponsor commitment for SD (MD)**
  - **initial SD/MD ratio favors SD and results in more commitment in favor of SD**

- **Potential Interventions:**
  - **use reliable system metrics to set SD/MD balance**
  - **arbitrarily set the SD/MD balance, particularly at the outset**
  - **advertise benefits from MD activities**

Assessment

SD (MD) Activities Affect SD (MD) Technical Maturation, Cost/Benefit

mm: ***Everything is MD*** ***mm:*** ***MD has not done anything for me***



Assessment

SD (MD) Activities Affect SD (MD) Technical Maturation, Cost/Benefit

- **Key Structures:**
  - **increasing activities (SD or MD) increases technology maturation**
  - **eventually it decreases cost/benefit ratio, since diminishing returns are reached**

- **Potential Interventions:**
  - **develop system cost/benefit metrics**
  - **make calculation of benefit of MD over SD a requisite of MD activities**
  - **temporarily accept high cost/benefit MD activities to produce benefit to attract funding/participation**

Assessment

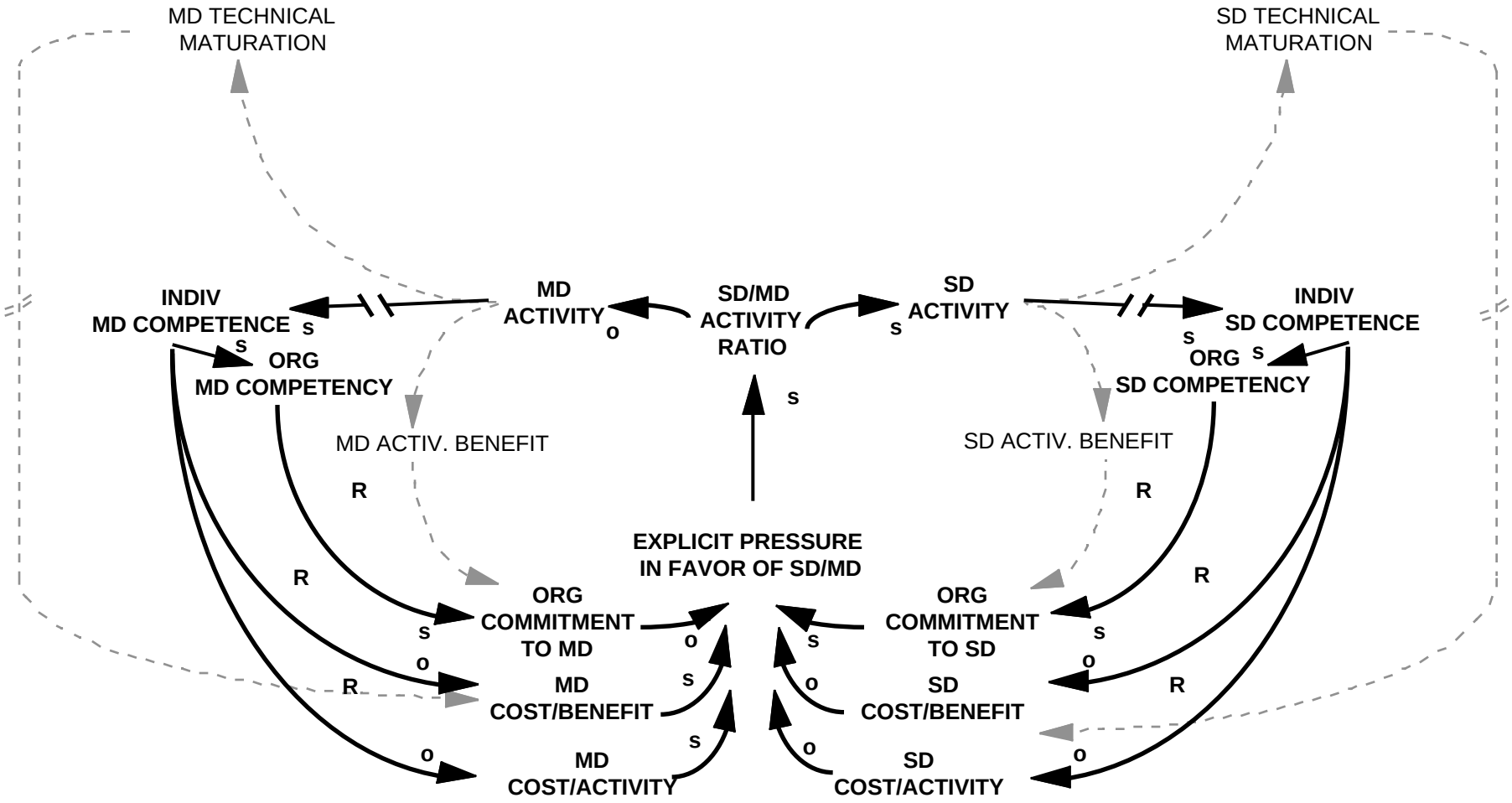
SD (MD) Experience Improves SD (MD) Competence/Competency

***mm:* IMD work has better cost/benefit**

***mm:* MD has not done anything for me**

***mm:* Everything is MD**

***mm:* IMD work is expensive**



Assessment

SD (MD) Experience Improves SD (MD) Competence/Competency

- **Key Structures:**
  - **Increased experience in SD (MD), increases indidual competence, therefore activity cost and cost/benefit.**
  - **If aligned, with core competency of organization, it is bound to increase organization commitment.**

- **Potential Interventions:**
  - **maintain an organization with an MD core competency**
  - **maintain an integration competency area in each SD organization**
  - **boost MD education, track and hire people with MD education/ experience**

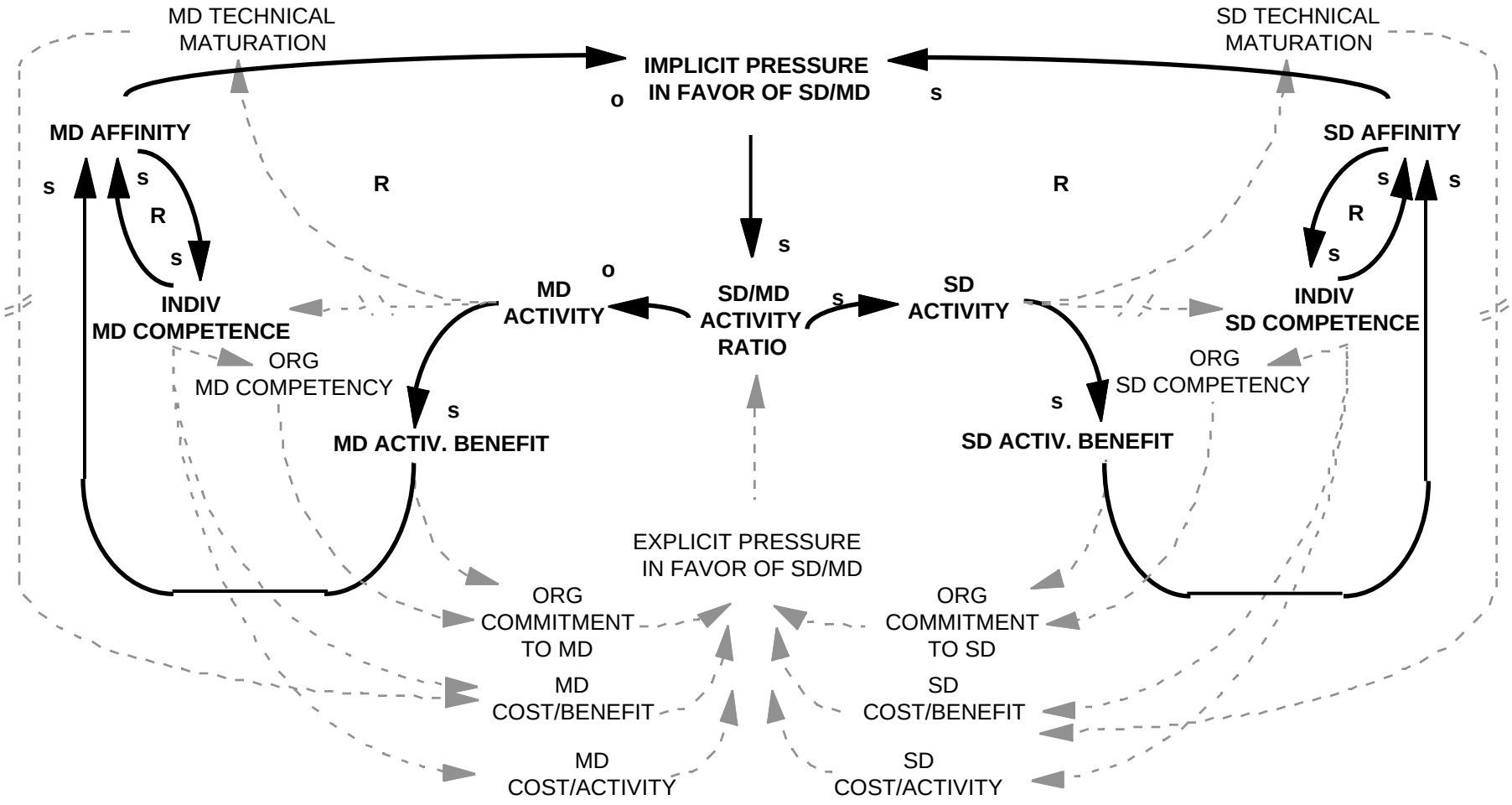
Assessment

SD (MD) Experience Increases Affinity for SD (MD) Work

***mm:* IMD work is not recognized**

***mm:* Iteam work is not rewarded**

***mm:* IMD work is not rewarded**



Assessment

SD (MD) Experience Increases Affinity for SD (MD) Work

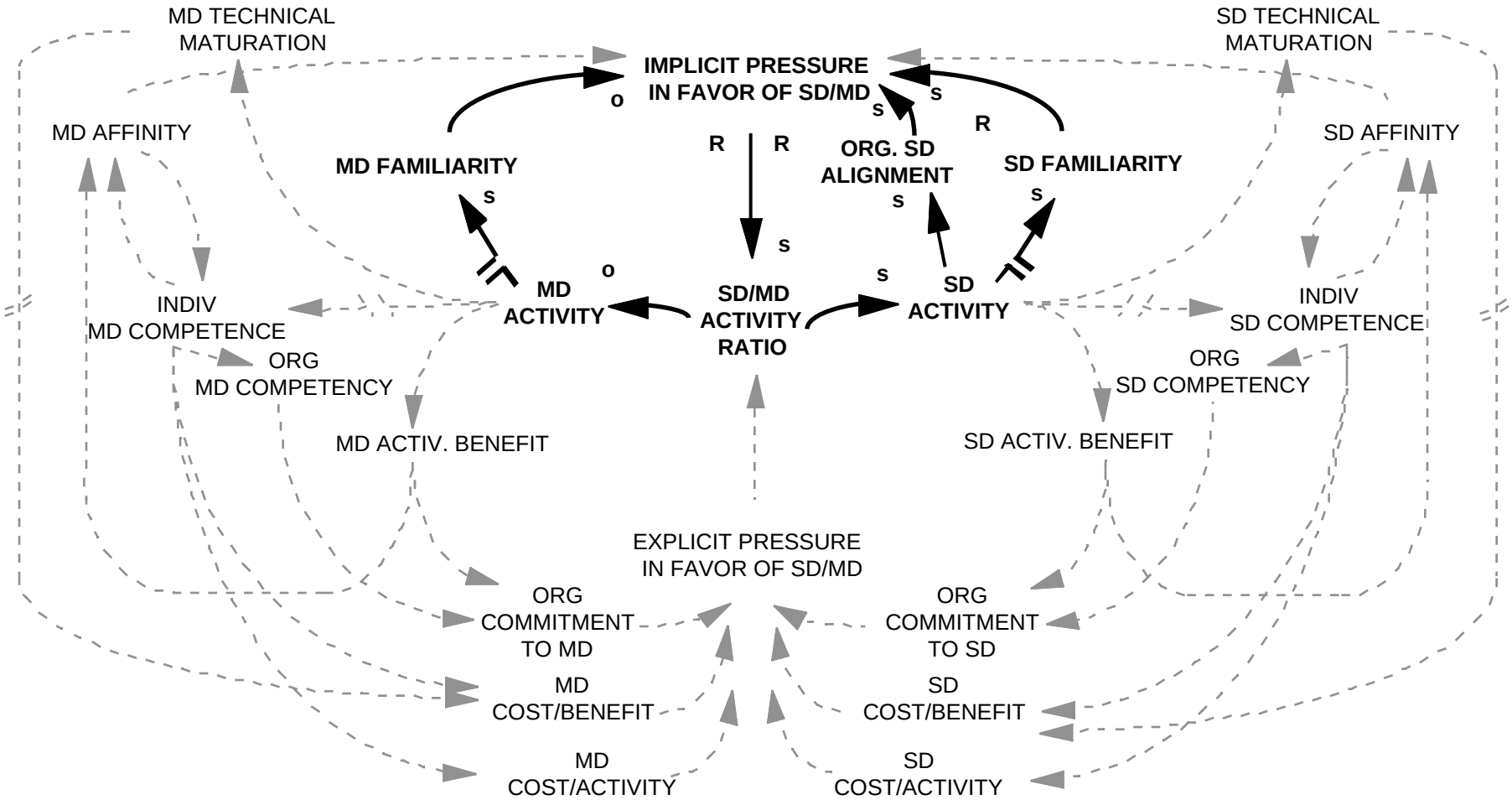
- **Key Structures:**
  - SD (MD) benefit results in researcher affinity for SD (MD), as reinforced by personal satisfaction, rewards, and recognition
  - SD (MD) affinity, reinforces SD (MD) competency
  - SD (MD) affinity increases pressure for SD (MD)

- **Potential Interventions:**
  - explicitly recognize team work
  - explicitly recognize MD work
  - explicitly reward MD work

Assessment

Long-term *Modus Operandi* Adds to Implicit SD/MD Pressure

***mm:* I prefer working in my comfort zone**



Assessment

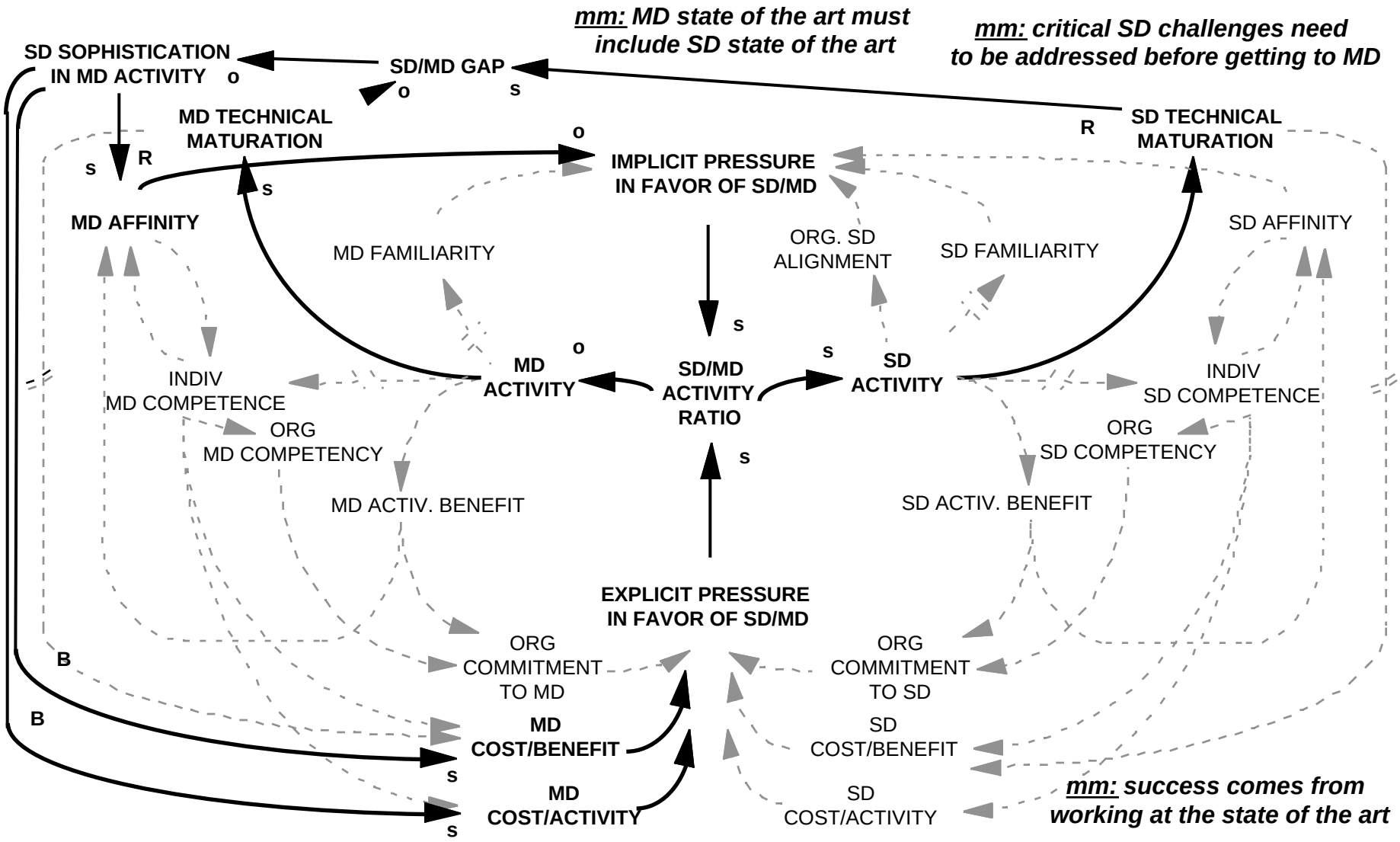
Long-term *Modus Operandi* Adds to Implicit SD/MD Pressure

- **<u>Key Structures:</u>**
  - **SD (MD) work reinforces individual familiarity with SD (MD) and therefore pressure in favor of SD (MD) work**
  - **LaRC heritage in SD work and its SD-aligned organizations maintain high SD/MD, therefore it reinforces line organization control and pressure for high SD/MD**
  - **a similar causal relationship does not exist on the MD side, as no organization is officially the keeper of MD applications**

- **<u>Potential Interventions:</u>**
  - **increase level of acceptable risk in SD, by conducting a higher proportion of fundamental work**
  - **maintain organization(s) that is (are) keeper of MD work**
  - **implement an effective matrix organization**

Assessment

SD (MD) Technical Maturation Affects SD/MD Gap



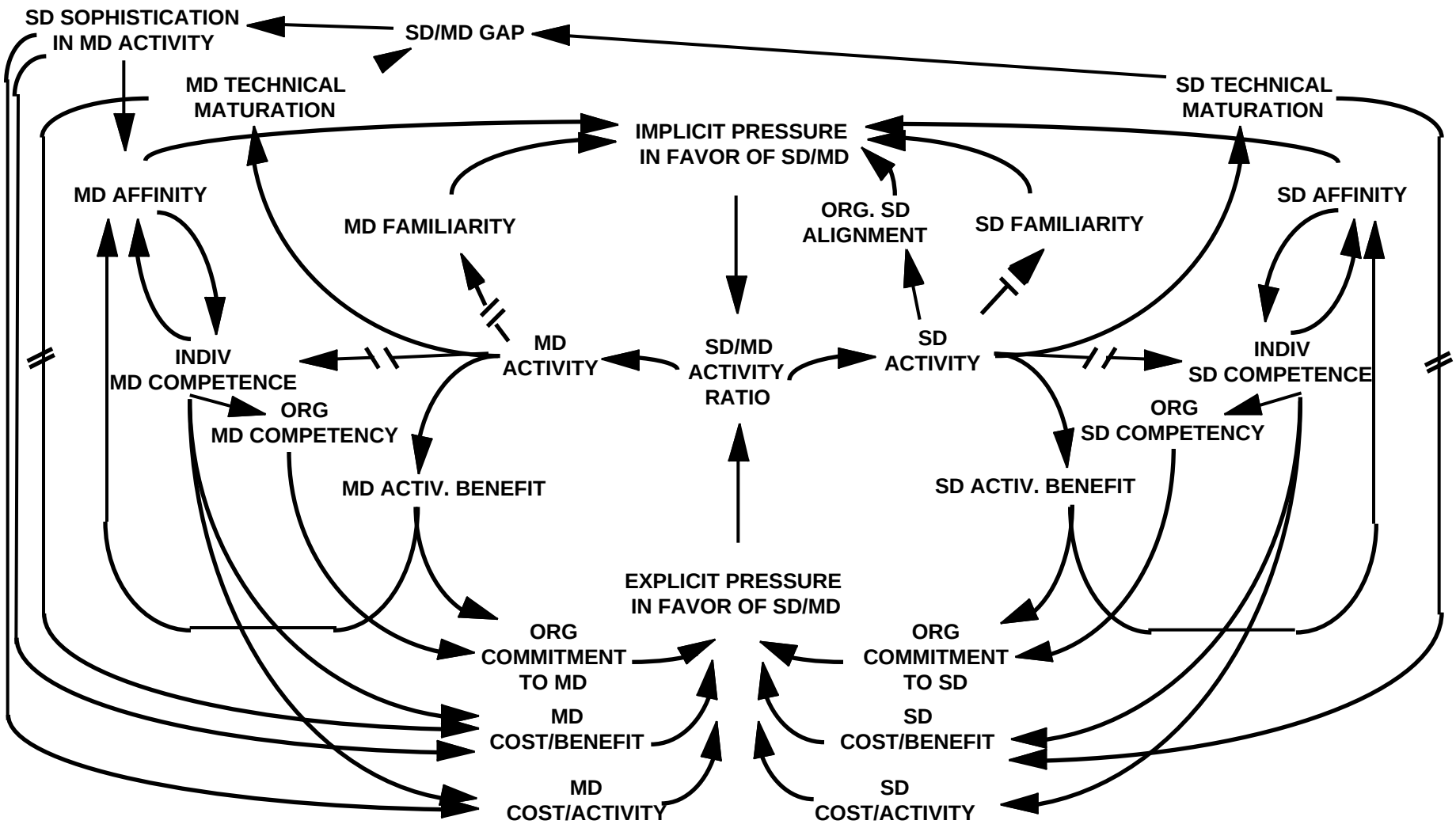
Assessment

SD (MD) Technical Maturation Affects SD/MD Gap

- **Key Structures:**
  - SD (MD) activities increase SD (MD) technical maturation
  - SD (MD) technical maturation increases (decreases) SD/MD gap
  - Increasing SD/MD gap decreases SD sophistication in MD applications
  - SD researcher looses affinity for MD and increases SD/MD implicit pressure
  - but, MD application cost and cost/benefit improve, thereby reducing SD/MD explicit pressure

- **Interventions:**
  - balance SD sophistication in MD work
  - include capability to work MD problems as key component of SD work

Summary

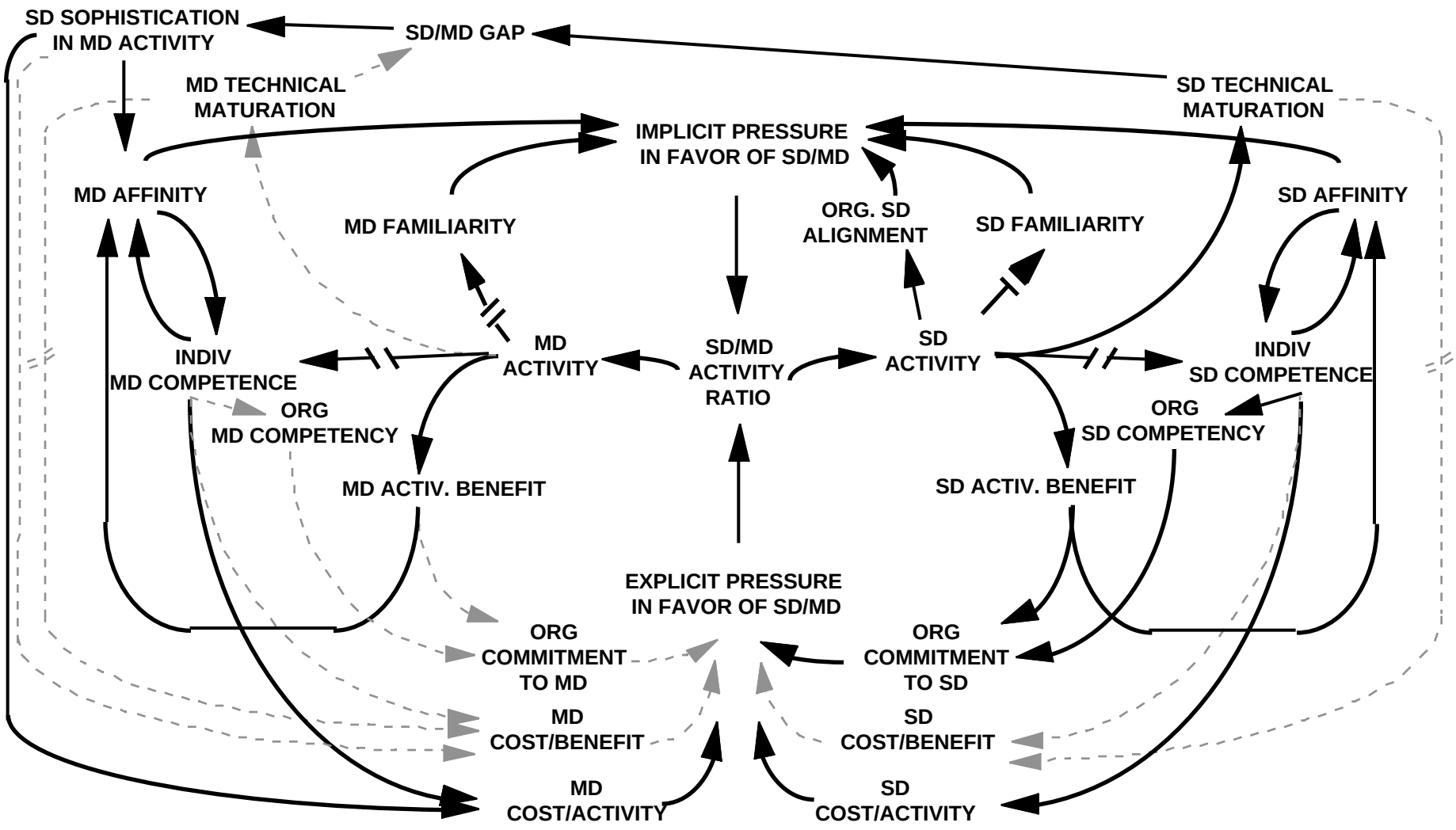

SD SOPHISTICATION IN MD ACTIVITY
SD/MD GAP
MD TECHNICAL MATURATION
SD TECHNICAL MATURATION
IMPLICIT PRESSURE IN FAVOR OF SD/MD
MD AFFINITY
MD FAMILIARITY
ORG. SD ALIGNMENT
SD FAMILIARITY
SD AFFINITY
INDIV MD COMPETENCE
MD ACTIVITY
SD/MD ACTIVITY RATIO
SD ACTIVITY
INDIV SD COMPETENCE
ORG MD COMPETENCY
ORG SD COMPETENCY
MD ACTIV. BENEFIT
SD ACTIV. BENEFIT
EXPLICIT PRESSURE IN FAVOR OF SD/MD
ORG COMMITMENT TO MD
ORG COMMITMENT TO SD
MD COST/BENEFIT
SD COST/BENEFIT
MD COST/ACTIVITY
SD COST/ACTIVITY

Summary

Comments

- The diagram is mostly symmetric as it follows the success-to-the-successful archetype
- The only non symmetric elements are introduced by:
  - the lack of infrastructure responsible for MD activities
  - the tension existing between the SD state-of-the-art and the capacity for MD to accommodate it
- The lower part of the diagram deals with explicit decision making questions for which some metrics are available, the upper part deals with implicit issues, more difficult to quantify
- Most loops are reinforcing, therefore, with the right interventions, they can be set in motion and become virtuous loops driving the process towards a more favorable SD/MD ratio

Operating Loops at LaRC



Operating Loops at LaRC

Comments

- **Cost benefit analyses on a system metric basis are difficult to make and to factor in decisions needed to balance the R&D portfolio; this affects both the SD and MD sides**
- **Aside from MDOB, there is no line organization that is the keeper of MD applications,**
  - **diagram asymmetry is accentuated**
  - **championing of MD work remains at the individual level**

Intervention Summary

Individual Researcher

- **In SD work**
  - **include capability to work MD problems as component of SD work**
  - **increase acceptable risk level, conduct more fundamental SD work**
  - **balance SD sophistication in MD work**

- **In MD work**
  - **advertise MD benefits**
  - **develop system cost/benefit metrics**
  - **balance SD sophistication in MD work**

Intervention Summary

Line Organization

- **Personnel Issues**
  - **explicitly recognize MD work**
  - **explicitly reward team work**
  - **explicitly reward MD work**
  - **boost MD education, track/hire people with MD education/experience**

- **Core Competency Issues**
  - **maintain an infrastructure to with an MD core competency**
  - **maintain an integration competency area within each SD organization**

Intervention Summary

Program Offices

- **Research Package Content**
  - **make calculation of benefit of MD over SD a requisite of MD activities**
  - **sponsor more fundamental SD work**
  - **require capability to work MD problems as a component of SD work**

- **Balanced Portfolio**
  - **use reliable system metrics to set SD/MD balance**
  - **arbitrarily set the SD/MD balance**
  - **temporarily accept high cost/benefit MD activities to produce benefit to attract funding/participation**